COMPOSITE LAMINATE HAVING A DAMPING INTERLAYER AND METHOD OF MAKING THE SAME

TECHNICAL FIELD

This disclosure generally relates to composite laminates used in structural applications, especially aircraft, and deals more particularly with a composite laminate having a reinforced interlayer that provides structural damping.

BACKGROUND

Composite materials such as carbon fiber reinforced epoxy resin are used in aircraft applications because of their light weight and high strength, compared to metals such as aluminum. More recently, these composite materials have been used in the fuselage structure which surrounds interior cabins in the aircraft. The use of composite materials in the fuselage structure presents an opportunity to reduce engine and aerodynamic noise, as well as vibration transmission to the interior of the aircraft.

In order to reduce noise and vibration, "add-on" parts may be installed on the aircraft which function to at least partially damp vibrations and noise to prevent propagation to the interior cabin. In order to adequately reduce noise and vibration, a relatively large number of these add-on parts may be necessary which are costly both in terms of material and labor installation costs. Moreover, these additional parts add to the weight of the aircraft.

Designing aircraft structures such as a fuselage having high inherent damping is particularly challenging when using composite materials. The composite material is typically cured at relatively high temperatures and pressures, in contrast to the operating conditions of the aircraft in which the fuselage skin typically encounters temperatures approaching −60° F. or lower at typical flight altitudes. Thus, engineering a damping material system that performs well at cold temperatures (normally requiring a very soft material) but can survive the heat and pressure when co-cured with the base material, may be particularly difficult. The ideal material that performs well at such cold operating temperatures has a very low glass transition temperature (Tg), such that it is in a soft transition phase at operating temperatures. Further, in order to use thin films of the damping material at these cold temperatures for low-weight applications, the modulus of elasticity of the material will typically be very low compared to the carbon/epoxy composite. Thus, the use of relatively soft materials to provide inherent damping within composite material structures may make it less stiff since the relatively soft damping material is substantially less stiff than the typical plies of carbon fiber reinforced plastics (CFRP), sometimes also referred to as organic composite materials.

Accordingly, there is a need for a composite material structure that has relatively high inherent damping qualities without materially reducing the stiffness and other mechanical performance characteristics of the structure. Embodiments of the disclosure are directed towards satisfying this need.

SUMMARY

An embodiment of the disclosure provides a damped composite laminate, which may include at least first and second layers of a reinforced resin material, and a third layer of damping material co-cured to first and second layers. The third layer of damping material may include a viscoelastic material having a reinforcement medium for stiffening the viscoelastic material. The reinforcement medium may include fibers embedded in the viscoelastic material. The fibers may have a length extending in a direction generally transverse to the planes of the first and second layers. The fibers may be formed of glass or carbon tow or a lightweight synthetic cloth, which are impregnated or coated with the viscoelastic material. The fibers may be formed of a second viscoelastic material, having a glass transition temperature greater than the glass transition temperature of the viscoelastic material in which the fibers are embedded. The third layer may include graphite nano-fibers or nano-tubes (Multi-wall (MWNT) or Single-Wall (SWNT)), or nano or micro sized particles dispersed within the viscoelastic material. The nano-fibers or nano-tubes or particles may be contained in a film of viscoelastic material, such as thermoplastic polyurethane.

In accordance with another embodiment, a composite laminate structure is provided, which may include at least first and second layers of a carbon fiber reinforced plastics (CFRP), and a third layer of reinforced viscoelastic material between the first and second layers. The viscoelastic material may be a thermoplastic polyurethane, or other highly damped polymer, such acrylic, or latex rubber. The third layer may not be continuous, but rather may have discontinuities that bridge between the first and second layer. The bridging may be accomplished with a narrow strip of high modulus carbon-organic resin prepreg, or slit-tape. The slit-tape may have a length that runs transverse to the longitudinal stiffeners of the aircraft fuselage. The bridging may also be accomplished by introducing perforations in the viscoelastic material that are filled with resin migrating from the first and second layers during curing. The bridging may be accomplished through the introduction of fiber tow that run perpendicular (Z-Fiber) to the first and second layers, through the thickness of the third layer. The length of these fiber tows may exceed the thickness of the third layer, such that their ends extend into the first and second layers. These fiber tows may consist of carbon or glass fibers and may be pre-impregnated with epoxy or suitable organic resins. The third layer is co-cured with the first and second layers so that the composite laminate is provided with a reinforced interlayer that provides inherent damping of the structure.

Another embodiment of the disclosure provides a method for making a damped composite laminate structure. The method may comprise the steps of placing a layer of damping material between first and second layers of carbon fiber reinforced plastic (CFRP) material, and co-curing the layer of damping material with the first and second layers. The co-curing is achieved by compressing the first and second layers with the layer of damping material, and co-curing the first and second layers along with the layer of damping material. The layer of damping material may be attached to the first layer following which the second layer is applied over the layer of damping material. The method may further include introducing reinforcement into the layer of damping material before co-curing is performed. The introduction of reinforcement into the layer of damping material may include providing a reinforcement medium and infusing the reinforcement medium with a viscoelastic material.

A further embodiment of the disclosure provides a method of making a composite laminate structure which may comprise the steps of forming first and second pre-pregs; forming a layer of damping material that provides the structure with damped qualities; forming a lay-up by placing the layer